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The vertical distribution of mysids in the Baltic Sea

N. A. Khaldinova, L. G. Nazvich, and M. V. Rein

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O vertikal'nom raspredelenii mizid v Baltiiskom more 75*

The vertical distribution of mysids in the Baltic Sea

N. A. Khaldinova, L. G. Nazvich and M. V. Rein

In studying the conditions of the formation of commercial accumulations of fishes, observations on the distribution of the living organisms, on which the fishes feed, are of important significance. Young and medium-aged fish of the Baltic cod [Gadus morhua callarias] feed mainly on nektobenthic animals: sea cockroaches** (Mesidothea entomon L.) and mysids (Mysidacea). Besides the cod, other fishes, such as the sprat [Clupea sprattus balticus], herring [Clupea harengus membras] and flounder [Pleuronectes flesus], also feed on Mesidothea entomon.

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* The numbers in the right-hand margin indicate the corresponding pages in the original text. (Tr.).
** Literal translation of Russian vernacular name. (Tr.).

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Observations on the vertical distribution of mysids in the Baltic Sea and in the Gulf of Riga were carried out by us in 1953 - 1955 in parallel with a study of the feeding and distribution of the cod.

Five species of mysids live in the Baltic Sea: Mysis mixta Lilljeborg, Mysis oculata var. relicta Loven, Neomysis vulgaris (J. V. Thompson), Praunus flexuosus Müller and Praunus inermis (Rathke). The first two species are widely distributed in the Baltic Sea; the remaining species live only in coastal waters at shallow depths (8). M. mixta, M. oculata var. relicta and N. vulgaris have the greatest significance in the feeding of fishes.

Apstein (9), who studied the biology of M. mixta in the Baltic Sea, on comparing the catches of mysids with a fingerling net in the upper layers of the water and catches with the same net with otter boards in the abyssal layers of the water, found that mysids are distributed through the water column, though he did not have sufficient data to reach a conclusion concerning the presence of daily vertical migrations in mysids.

Bodnek (1) reports that in the autumn in the Gulf of Riga mysids were found in the uppermost layers of the water at night and at 08.00 in the morning, while during the day they moved down into the deep layers. In the opinion of that author, during the summer (July - August) the mysids, as cold-water forms, do not rise up into the upper and middle layers of the water. The author notes, however, that the biomass of the mysids was not taken into consideration because of the lack of special fishing apparatus.

Sushkina (7) established that the biomass of the mysids in the benthopelagic layers of the Gulf of Riga increases in a regular fashion during the day. The mysids were caught in the second half of October with a small ichthyoplankton net, attached to the head line of an otter-trawl.

Nikolaev (5) indicates that the span of the vertical migrations of mysids in the Baltic Sea is as much as 150 - 200 m from the bottom.

Mysids are comparatively large and quite mobile crustaceans and therefore the normal plankton net and bottom dredge are not very suitable for catching them. For studying the distribution of mysids in the water column during the course of the day we netted the different horizons of the water along the vertical with a large ichthyoplankton net, made of No. 140 gauze and with an 80 cm diameter of the entry opening, provided with a closure device.

For characterizing the benthopelagic distribution of 76
the mysids we carried out a five-minute netting with a Rass trawl (6), onto the frame of which we mounted a large ichthyoplankton net. Furthermore, we conducted numerous one-hour or half-hour netting with a trawl net (Genzen's*) of No. 14 gauze with a 12 cm diameter of the entry opening, which was fastened to the head line of an otter-trawl. The area of the entry opening of the ichthyoplankton net and the Rass trawl comprised 0.5 m^2, while the area of the trawl net was 0.11 m^2.

The catches of the mysids with the ichthyoplankton net were counted in specimens, while the catches with the trawl were measured by a volumetric method (in cm^3) by means of a

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* "set' Genzena" - could be "Gensen's net" or "Hensen's net". (Tr.).

measuring cylinder. We did not recalculate the mysids per unit area or volume of the water. In total we processed 160 samples collected with the ichthyoplankton net, 94 samples taken with the trawl net and 36 samples gathered with a hydrobiological trawl. The length of the mysids was measured from the middle of the eye to the end of the telson.

In view of the fact that the rhythm of the daily migrations of mysids is considered in connection with the illumination intensity, we present the times of sunrise and sunset on the days of our observations.

	Sunrise	Sunset
April	05.00	20.00
May	04.25	20.21
June	04.00	21.00
August	04.30	20.32
October	07.25	17.25
December	08.00	16.30

Observations made in the Gulf of Riga in May 1954 showed that in the evening after sunset the mysids were distributed in the middle layers of the water, at night (24.00 - 01.00 hours) they were located in the 0 - 15 m horizon, and before sunrise they descended into the lower horizons of the water. During the daylight hours mysids were not found in the pelagic layers of the water.

The distribution of mysids in the water column at different times of day on May 12 - 13, 1954, in the Gulf of Riga is shown in Table 1.

M. mixta predominated in the catches, comprising 80% of the catch. M. oculata var. relicta made up 19% and N.

Table 1

Таблица 1

A Горизонт лова в м	B Распределение мизид над глубинами 30–40 м в шт. при наблюдении в час. и мин.						
	22.20–23.20	23.45–24.00	0.45–1.00	4.25–5.10	5.30–5.55	6.50–7.05	9.00–10.00
All species of mysids Все виды мизид							
0–10	1	0	345	0	0	0	0
10–20	23	49	20	0	0	0	0
20–30	34	5	0	93	0	0	1
30–40	4	8	—	37	41	0	—
Итого... Total	62	62	365	130	41	—	1
M. mixta							
0–10	1	0	332	0	0	0	0
10–20	6	32	11	0	0	0	0
20–30	8	4	0	90	0	0	0
30–40	2	3	—	21	1	0	—
Итого... Total	17	39	343	111	1	—	—
M. oculata var. relicta							
0–10	0	0	13	0	0	0	0
10–20	11	8	8	0	0	0	0
20–30	22	0	—	0	0	0	1
30–40	2	5	—	15	35	0	—
Итого... Total	35	13	21	15	35	—	1
N. vulgaris							
0–10	0	0	0	0	0	0	0
10–20	2	2	0	0	0	0	0
20–30	0	0	0	3	0	0	0
30–40	0	0	—	0	1	0	—
Итого... Total	2	2	—	3	1	—	—

A - Netting horizon in m

B - Distribution of mysids over depths of 30-40 m in individuals, with observations in hours and minutes

vulgaris - 1% of the total number of mysids. M. mixta in the catches was represented predominantly by young specimens from

3 to 6 mm in length, while M. oculata var. relicta was represented by individuals from 3 to 11 mm in length. The maximal length of adult M. mixta was 21 mm, while that of M. oculata was 26 mm; N. vulgaris had dimensions ranging from 7 to 14 mm. If large mysids do not avoid being caught by an egg net *, then it may be assumed that M. mixta adults reached the upper layers of the water later than the young individuals and, possibly, descended to the bottom earlier. Adults of M. oculata var. relicta were found only in the lower 20-meter layer, while the young individuals ascended to higher levels. Migrations of the young of M. mixta, that were more clearly expressed than in the adults, were also found by Apstein (9) in the Gotland basin in November.

Data on the distribution of (A) small (3 - 12 mm) and (B) large (13 - 26 mm) mysids in the water column on the night of May 12 - 13, 1954 (as % of the total number of all the individuals of the given species caught) are presented in Table 2.

The presence of from 5 to 53 M. mixta mysids in the upper 50-meter layer of the water during the night and their absence during the day was noted by us in the regions of Ventspils, Liepaja, Pionerskiy and in the Gdańsk basin at the end of April - beginning of May 1954, and also in the middle of August 1953 at a 24-hour station to the west of Saaremaa Island and on the western slope of the Gotland basin. The use of an ichthyoplankton net having a larger mesh size (13 per 1 cm) than the usual plankton net (22 per 1 cm) permitted us to establish the vertical migrations of mysids in the summer.

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* "ikornaya setka" - egg net - a plankton net of mesh suitable for taking pelagic fish eggs. (Tr.).

Table 2

Таблица 2

Горизонт лова в м	Распределение мизид в % при наблюдении в час. и мин.							
	22.20 - 23.20		23.20 - 24.00		0.45 - 1.00		4.25 - 5.10	
	А	Б	А	Б	А	Б	А	Б
M. mixta								
0 - 10	0,2							
10 - 20	1,2		6,3		64,7	0,4		
20 - 30	0,2	1,4	0,8		2,1		7,6	
30 - 40		0,4	0,4	0,2			3	0,8
M. oculata var. relicta								
0 - 10					15,4			
10 - 20	13,1		9,5		9,5			
20 - 30	14,3	11,9						
30 - 40	2,4			6,0			11,9	6,0

A - Netting horizon in m

B - Distribution of mysids in percentages with observations in hours and minutes

In August 1953 in coastal regions (from the Irbenskii Strait to Liepaja) individual specimens of mysids were found in the upper 20-meter layer of water above depths of 33 - 68 m not only during the night, but also from 06.00 to 08.00, at 11.00 and at 19.00 hours. The finding of mysids during the day in the upper layers of the water (May) was also reported by Apstein (9), but in our catches such large numbers of mysids near the surface of the water (according to Apstein, up to 316 - 450 specimens) were not found during the day. The differences in the quantitative indices may possibly be explained by the fact that we caught the mysids by drawing the net along the vertical, while Apstein drew the net along the horizontal.

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Table 3

Таблица 3

A Горизонт лова в м	B Распределение мизид (в шт.) над глубинами в м*						
	165	202	144	185	230	232	137
	C время наблюдений в час. и мин.						
	12–14	11–15	17–19	19.30–21	20.30–23.40	21–1	24–2
0–70	0	0	0	0	0	0	0
70–100	0	1	0	0	0	2	1
100–150				8	16		
150–дно	6	17	4	0	15	6	7
d Протяженность миграций в м	—	102–132	—	35–85	80–130	132–162	67–37

* Придонный слой воды высотой от 2 до 7 м не облавливался; на глубинах 230 и 232 м высота его составила 45 и 65 м; с 24 до 19 часов от дна до 100 м проводили тотальный лов.

A - Netting horizon in m

B - Distribution of mysids (individuals) above depths in m

c - times of observation in hours and minutes

d - Span of migration in m

* The benthopelagic layer of water, from 2 to 7 m in height, was not netted; at depths of 230 and 232 m its height was 45 and 65 m; from 24.00 to 19.00 hours total netting from the bottom to 100 m was carried out.

In May - June 1954 in the Gotland and Northern basins, above depths of from 100 to 230 m, M. mixta comprised 59% and M. oculata var. relicta made up 41% of the total number of mysids caught. In the Gotland basin, at depths of from 140 to 230 m, M. mixta predominated (58%) in the catches in May, while in June M. oculata var. relicta (75%) predominated.

Above depths of 140 - 230 m the mysids did not ascend above the 70-100 m horizon from the water surface (Table 3), while in August above a depth of 112 m we found mysids throughout the whole water column at night (01.30 - 03.30)[1]. It is

[1] Station conducted on 14 August 1953 on the western slope of the Gotland basin (57°21′ lat. N.; 19°31′ long. E.) in calm weather, while the ship was standing at anchor.

possible that in the deep-water sections of the Baltic Sea the mysids do not ascend at night into the upper layers of the water. Special studies should be carried out to clarify this question. Our observations at the deep-water stations allow us to note that mysids ascend to 130 - 160 m above the bottom in the Baltic Sea, while in the Caspian Sea the daily migrations of mysids attain a span as great as 250 - 350 m (3). 79

Data on the distribution of the mysids are presented in Table 3 (Gotland basin from May 20th to June 9th, 1954).

The data on the distribution of mysids in the benthopelagic layer, based on catches with the trawl net, should be considered as most reliable only for the daytime period, when the mysids remain near the bottom. Nocturnal catches (when there is no closure device on the net) may be explained in part by mysids getting into the net in the water column during the lowering or raising of the trawl, or in the upper layer of the water during the turning circle before the trawl is lowered to the bottom.

During the summer mysids were caught in the trawl net not only during the night but also during the day, while during the autumn and winter they were caught in this way only during the dark period of the day. If one excludes the indeterminable features of the catch, possible with different rigging of the otter trawl or speed of trawling, then one may assume, from a comparison of the daytime catches, that the mysids keep to a narrower benthopelagic layer of the water during the autumn and winter than during the summer.

The catches of mysids with the trawl net in the Baltic Sea at depths of 10 - 80 m (in cm^3 per hour of trawling) are presented in Table 4.

Table 4

Таблица 4

A Дата наблюдений	E Уловы мизид притраловой сетью (в $см^3$) на глубине 10—80 м за час лова при наблюдении в часах																	
	2	3	4	5	6	7	8	9	10–16	17	18	19	20	21	22	23	24	1
b Июль—август 1953 г.	+++ 30	++++	++	50		5	20	0–2 (среднее 0,4)*		0,5	0		+++ 30	+++ 60	+++	+++	++++	+++++
c Октябрь 1955 г.	+++ 0	++++ 0	+++ 1,4	++++	+++ 0,4		0	0–0,05 (среднее 0)**		+++	+++	+++ 0	++++ 0,2	+++	+++ 0,4	+++	+++ 4	+++++ 0
d Декабрь 1954 г.	+++	++++	+++	++++	+++	+++ 2	0,05	0+		++++ 2	+++	+++	+++	+++ 0,7	+++	+++ 0,1	++++ 0,5	+++++

Примечание. Темное время суток от захода до восхода солнца показано крестиками.

A - Date of observation

b - July - August 1953
c - October 1955
d - December 1954

E - Catches of mysids with a trawl net (in cm^3) at a depth of 10 - 80 m per hour of trawling with observations in hours

* 0 - 2 (average 0.4)

** 0 - 0.05 (average 0)

Note. The dark period of the day from sunset to sunrise is indicated by crosses.

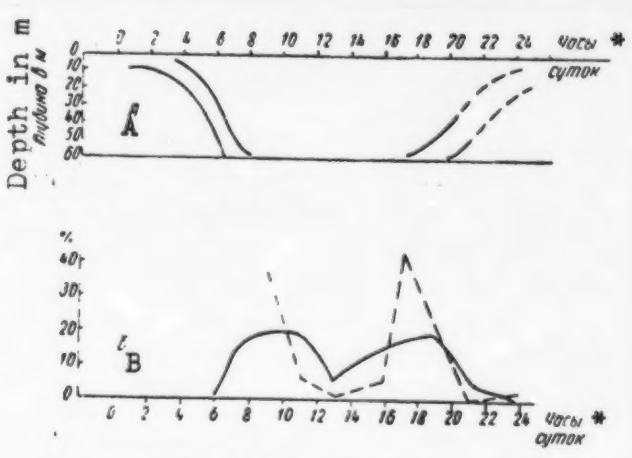

Рис. 1. Распределение мизид:
А—весной и летом в толще воды (верхняя и нижняя границы распределения мизид); *Б*—летом (сплошная линия) и осенью (пунктир) у дна (в % от всего вылова за сезон).

Figure 1. Distribution of mysids:

A - in the spring and summer in the water column (upper and lower boundaries of the distribution of mysids);

B - in the summer (continuous line) and in the autumn (dashed line) at the bottom (in percentages of the total catch for the season).

* - Times (hours) of day.

The distribution of mysids at the bottom (B) and in the water column (A) is shown in Figure 1. The distribution of the mysids at night in the water column is illustrated on the basis of catches with an ichthyoplankton net in May - August 1953 - 1954, while at the bottom it is based on catches with a Rass trawl in July - August 1953 and in October 1955 at a depth of from 30 to 70 m. 80

The mysid catches at the bottom increase before sunset and in the morning, i.e. at the times of the ascent and descent of the mysids to the bottom, and they decrease after sunset. At this time the mysids are found in the water column (A). The daytime minimum in the catches (B) may be explained by the fact that at this time the mysids have descended down onto the bottom.

There were no observations on the distribution of the mysids according to the horizons from 20.00 to 22.00 hours (Figure 1, A), but, on the basis of the fact that the biomass of mysids at the bottom decreases from 20.00 to 21.00 hours (Figure 1, B), while the mysid catches with a trawl net increase at a certain distance from the bottom (Table 4), and also taking into account that from 22.00 to 23.00 hours the mysids are already distributed throughout the whole water column (Figure 1, A; Table 1), it may be considered that during the summer at a depth of up to 50 - 70 m the ascent of the mysids commences between 20.00 and 21.00 hours *, i.e. during the hours of sunset. At a great depth, where twilight commences earlier, the mysids were already found at this time high above the bottom (Gotland basin, 22 June; Table 3).

During the autumn and winter the vertical ascent of mysids commences earlier, at 17.00 - 18.00 hours (Figure 1, B; Table 4), and the descent to the bottom begins later, than during the summer. During the spring and summer the mysids are found in the water column from 20.00 - 21.00 hours to 05.00 hours. Massive numbers of mysids in the upper 20-meter layer of the water are found from 23.00 to 04.00 hours. The descent of the mysids to the bottom apparently proceeds more rapidly than their ascent into the upper horizons of the water.

In October we found the largest catches of mysids in the benthopelagic layer of the water during the morning and evening twilight and during these hours mysids were encountered more frequently in the stomachs of young cod (Figure 2).

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* The observations of I. I. Nikolaev (4) showed that in June 1955, at a depth of 60 m, mysids remained near the bottom until 20.00 hours, and ascended into the water column from 21.00 to 22.00 hours.

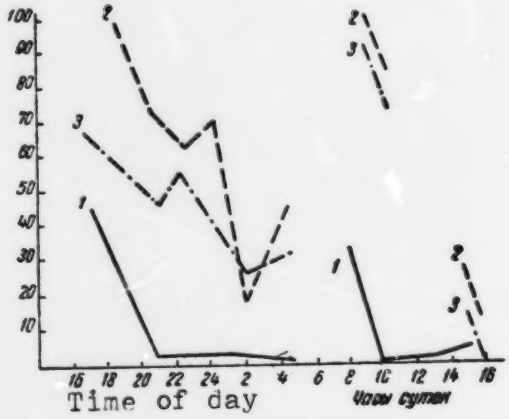

Рис. 2. Суточные изменения плотности скоплений мизид у дна и частота встречаемости их в желудках трески в октябре 1955 г. (глубина 40—60 м):

1—биомасса мизид (в % от общего вылова); 2—частота встречаемости мизид в желудках трески длиной до 25 *см*; *3*—частота встречаемости мизид в желудках трески длиной от 26 до 35 *см*.

Figure 2. Daily changes in the density of accumulation of mysids near the bottom and the frequency of occurrence of mysids in the stomachs of cod in October 1955 (depth 40 - 60 m):

1 - biomass of mysids (as percentage of total catch);
2 - frequency of occurrence of mysids in stomachs of cod up to a length of 25 cm;
3 - frequency of occurrence of mysids in stomachs of cod from 26 to 35 cm in length.

Evidently, the main feeding of young cod on mysids proceeds at the times of the ascent of the mysids above the bottom and their descent onto the bottom.

Mysids lead a gregarious way of life (2) and they form 81
accumulations of varying density in the benthopelagic layers. Catches of mysids in July 1953 and in October 1955 in the region of Klaipeda fluctuated from a few specimens to 1.6 million individuals per five minutes of trawling. A judgement on the uneven, spotty distribution of mysids and on the increase in their biomass with increasing depth may be derived from Figure 3.

Table 5

Таблица 5

A Дата наблюдений	D Время наблюдений в час и мин.	E Районы	H Средние уловы (в $см^3$) мизид за пятиминутный лов тралом на глубинах в м											
			10–20	20–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–130	130–240
b 27 июля – 23 августа 1953 г.	6–23	f От Клайпеды до Хиума	–	–	50	107	255	420	18	–	67	304	0,08	0,08
c 22 октября 1955 г.	9.20–12.50	g Клайпеда	100	15	–	–	40	–	500	–	–	320	–	–

A - Date of observation: b - 27 July - 23 August 1953
c - 22 October 1955

D - Times of observation in hours and minutes

E - Regions: f - From Klaipeda to Hiiumaa
g - Klaipeda

H - Average catches (in cm^3) of mysids per five-minute trawling at depths in m.

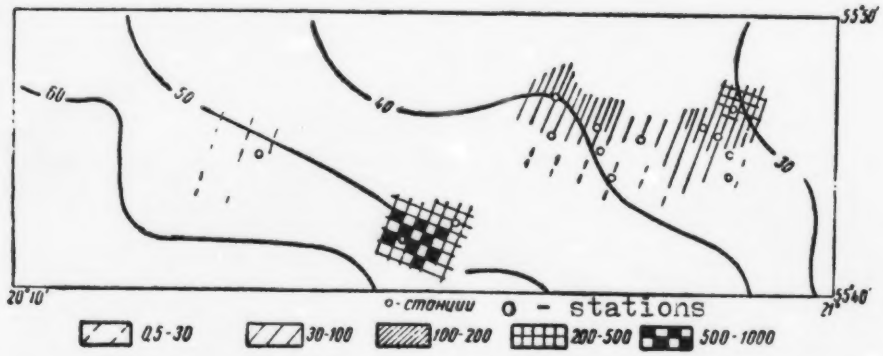

Рис. 3. Распределение M. mixta у дна в районе Клайпеды в конце июля 1953 г. (в $см^3$ за пятиминутный лов тралом).

Figure 3. Distribution of M. mixta near the bottom in the region of Klaipeda at the end of July 1953 (in cm^3 per five-minute trawling).

The average catches of mysids at different depths in a five-minute trawling (in cm^3)* are shown in Table 5, from which it can be seen that the largest accumulations of M. mixta were found at a depth of from 45 to 70 m, and that they decreased drastically with an increase in the depth.

* On average about 20 mysids are contained in 1 cm^3.

Table 6

Таблица 6

Районы Regions	Depth Глубина в м in m	Time of Часы лова catch	A Число тралений	B Средние уловы в см³
Вентспилса Ventspils	30–65	7–19	6	222
Клайпеды Klaipeda	30–65	9–19	11	229
Лиепаи Liepaja	40–55	18; 21	2	13
Сарема Saaremaa	50–65	6; 22	2	0
Хиума Hiiumaa	65–70	19	1	300
Готландской впадины Gotland basin	129–208	14	2	0,03
Итого Total		6–22	24	138

A - Number of trawlings
B - Average catches in cm^3

According to Shurin (8), M. mixta and M. oculata var. relicta are distributed in the Baltic Sea at depths of from 10 to 160 m, while N. vulgaris, P. inermis and P. flexuosus are found in shallow waters, no deeper than 30 - 40 m.

In our collections M. mixta and M. oculata var. relicta were found at depths of up to 200 - 230 m. 82

Average catches of mysids in different regions of the Baltic Sea at the end of July and in August 1953, in cm^3 in five minutes of trawling with a Rass trawl, are presented in Table 6.

The data in this table indicate that the highest average catches of mysids were in the regions of Hiiumaa, Ventspils and Klaipeda.

In the other regions the mysid catches were insignificant. To the west of the southern tip of Saaremaa Island mysids were not found at the bottom at a depth of 70 m (trawling at 06.00 in the morning and late in the evening at 22.40),

though they were found in large numbers at night (at 03.00 - 04.00 hours) in the pelagic zone.

CONCLUSIONS

1. Mysids perform daily vertical migrations in the Baltic Sea. In the evening, before sunset, mysids ascend into the pelagic zone, and in the morning, at sunrise, they descend to the bottom.

2. In the autumn, in connection with the shorter day, the ascent of the mysids commences earlier and the descent begins later than during the summer.

3. In those regions where the total depth is as much as 230 m the mysids ascend to 130 - 160 m above the bottom.

4. Young individuals ascend earlier and to higher levels than do adult mysids, and they descend later.

5. Mysids are distributed unevenly in the benthopelagic layer of the water, forming accumulations of varying density. During the summer and autumn the largest accumulations of mysids were found at depths from 45 to 70 m. At these depths in the autumn and winter the mysids kept themselves near the bottom during the daylight hours, apparently in a very narrow layer of water, while during the summer they are found in a wider layer.

6. During the autumn young cod feed on the mysids in the morning and evening, i.e. at the time of their descent to the bottom and at the beginning of their ascent up from the bottom.

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